

REMARKS

The Office Action dated October 19, 2004 has been received and carefully reviewed. The preceding amendments and the following remarks form a full and complete response thereto. Claim 12 has been amended with respect to form only. Claim 13 is also amended. No new matter has been added and no amendments made that narrow the scope of any elements of any claims. Accordingly, claims 1-15 are pending in the application and submitted for reconsideration.

Claim 12 was rejected under 35 U.S.C. § 112, second paragraph. Clearly, as originally written, claim 12 was intended to depend from claim 11. Therefore, claim 12 was amended to depend upon claim 11 instead of claim 10. Applicants submit that claim 12, as amended, complies with the requirements of 35 U.S.C. § 112. Accordingly, Applicants request that the rejection of claim 12 be withdrawn.

Claims 1-4, 10 and 13-14 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,591,795 to Janak. Applicants respectfully traverse the rejection and submit that claims 1-4, 10 and 13-14 each recite subject matter not shown or disclosed by Janak.

Claim 1, upon which claims 2-4 depends, defines a valve actuation system for use in an internal combustion engine having at least one combustion cylinder having a piston in an engine valve. The valve actuation system includes a hydraulic pump configured to produce a hydraulic output based on the valve-piston clearance profile of

at least one cylinder of the combustion engine. This valve actuation system also includes a high-pressure reservoir coupled with the hydraulic pump. An electro-hydraulic valve actuator is coupled with the high-pressure reservoir and configured to actuate at least one engine valve of the combustion engine according to an output of the hydraulic pump.

Claim 10 defines a valve actuation method for use in an internal combustion engine having at least one combustion cylinder having a piston and an engine valve. The engine includes an electro-hydraulic valve actuation system for opening and closing the engine valve. The valve actuation system includes a hydraulic pump including a plunger mechanically coupled with a cam. The cam moves the plunger to create hydraulic pressure and is mechanically coupled to an engine crankshaft. The electro-hydraulic valve actuation system also includes a second plunger that is fluidly connected with the hydraulic pump and mechanically connected with the engine valve for opening and closing the engine valve. The method includes the steps of: determining a piston-valve clearance profile of the piston and the engine valve for the at least one combustion cylinder; and selecting a shape of the cam of the hydraulic pump based on the piston-valve clearance profile, such that the plunger moves toward the cam when valve-piston clearance of the piston and the engine valve approaches zero.

Claim 13, upon which claims 14-15 depend, defines an electro-hydraulic valve actuation system for use in an internal combustion engine comprising at least one

combustion cylinder having a piston and an engine valve. The electro-hydraulic valve actuation system includes a pump means for producing a hydraulic output based on a valve-piston clearance profile of at least one cylinder of the combustion engine. The system also includes a valve actuation means for actuating at least one engine valve of the combustion engine according to an output of the pump means.

Numerous advantages result from the claimed configuration. One advantage of the claimed invention is that by using a cam shape based upon the piston-valve clearance curve, as the piston is moving close to the valve, the high-pressure starts to drop and piston-valve collision is prevented. The claimed configuration has the versatility of an electro-hydraulic actuator in combination with a mechanically actuated fail safe mechanism. As such, the claimed system is capable of allowing the opening timing of the engine valve to be controllable (e.g., electronically by the actuation of a solenoid), while still keeping the feedback loop for piston-valve contact protection. Further, timing can be separate from engine valve lift. By using the piston-valve clearance profile information in the design of cam lobe, the engine valve can safely open as early as possible without hitting the engine piston.

Applicants submit that Janak describes a primitive lost motion system and fails to disclose an electro-hydraulic actuation system, as presently claimed. One major difference between the lost motion system of Janak and the system described in the subject application is that lost motion systems do not have a solenoid valve between

the master piston (104b) and the slave piston (102e), as shown on Figure 1 of the subject patent application. See, e.g., Fig. 1 of Janak. In a lost motion systems, the hydraulic source is directly coupled with the engine valve. In Janak, as a result, the time delay is fixed from the moment that the master piston (104b) moves until just before the moment that the slave piston (102e) moves downward. In other words, the opening timing of the engine valve is fixed, unlike the present invention, which is electronically controlled.

Further, Applicants submit that Janak fails to describe using an entire piston-valve clearance profile in designing cam lobe as in the present invention. The second half of the piston-valve clearance profile (after piston moves away from the closest location to the engine valve) is clearly not used because of the drawback of a lost motion system described above, and as a result, the device of Janak cannot achieve the results of the claimed invention. See, e.g., Fig. 6 of Janak.

With respect to claim 13, Janak fails to describe a system that uses a cam lobe design having a geometry based on piston-valve clearance profile as described in the present specification. Claim 13 includes means-plus-function elements which, under 35 U.S.C. § 112, paragraph 6, by law, incorporates into the claim the corresponding structure or acts in the specification. Therefore, claim 13 requires that a piston-valve clearance profile as shown in Fig. 2 be described, or an equivalent thereof. Janak fails

to show or suggest using an entire piston-valve clearance for the purpose of constructing the shape of the cam lobe.

Thus, in view of the foregoing, Janak fails to show or describe each and every element of claims 1-4, 10 and 13-14. Accordingly, Applicants request that the rejection of claims 1-4, 10 and 13-14 be withdrawn.

Claim 15 was rejected under 35 U.S.C. § 103a as being unpatentable over Janak in view of U.S. Patent No. 5,537,976 to Hu.

Claim 15 depends from claim 13, which as described above, is patentable over Janak. Claim 15 is therefore patentable over Janak for at least the same reasons. Hu does not cure the deficiencies of Janak. Hu is directed to a "two-cycle" compression breaking scheme. That is, during breaking, a 4-stroke engine is converted to a 2-stroke cycle. Hu, like Janak, describes a lost motion type system and not for an electro-hydraulic valve actuation system as defined by claim 15. See, e.g., Abstract and Figs. 1 and 5, of Hu. Further, Hu does not teach or suggest the use of a valve-piston clearance profile for selecting the geometry of the cam. Thus, Applicants submit that the combination of Hu and Janak fails to show or suggest each and every feature of claim 15. Accordingly, Applicants request that the rejection be withdrawn and claim 15 be allowed.

Claims 1-4, 10 and 13-14 were rejected under 35 U.S.C. § 103 as being unpatentable over Hu in view of U.S. Patent No. 6,092,495 to Hackett. Applicants

respectfully traverse the rejection and submit that the combination of cited prior art fails to show or suggest each and every element of claims 1-4, 10 and 13-14.

As described above, Hu is directed to a lost motion machine and does not disclose the use of a valve-piston clearance profile for selecting the geometry of the cam. Hackett describes an electro-hydraulic system that relies totally upon electronic actuation and control, and has no mechanical fail safe features such as a feedback loop. See, e.g., col. 9, ll. 5-23 of Hackett. Hackett prevents piston-valve contact by calculating the piston position and estimate the future position of the piston and valve, and using electronic valve control to prevent collision. Thus, Fig. 2 of Hackett is not showing the piston-valve profile, and Hackett does not show, describe or suggest a cam shaft designed based on the piston valve clearance. Specifically, Hackett does not show or suggest a cam lobe that lowers the pressure when the piston moves close to the valve (i.e., when the distance between the valve and the piston is close to zero).

In contrast to Hackett, in the subject Patent Application, the piston-valve clearance information is "stored" on the cam lobe design. Therefore, the safety design will work even when the valve control system fails because it does not rely on any electronic device. This is substantially different than Hackett's patent.

In contrast to the present invention, Hackett's system relies on electronic control to actively keep the engine valve away from piston. See Fig. 2 and the accompanying description, in Hackett. The piston-valve clearance information is digitally stored in an

electronic control unit. The electronic control relies on sensors (temperature sensor, pressure sensor, crankshaft position sensor, etc.). Thus, Hackett fails to describe or suggest the cam lobe design claims in claims 1-4, 10 and 13-14 of the present invention. Because Hackett is a completely electronically actuated system, if somehow the valve control system fails, Applicants submit that it is unlikely that the electronic feedback control loop will be able to prevent piston-valve contact.

Further, there is no suggestion to combine Hu with Hackett. That is, Hu is a contact-free lost motion system and would not benefit from an electronic means for preventing piston-valve collision, as described by Hackett. Additionally, Applicants submit that the references as so combined still fail to disclose or suggest each and every element of claim 1-4, 10 and 13-14. Accordingly, Applicants request that the rejection be withdrawn and claims 1-4, 10 and 13-14 be allowed.

Claims 5-9 were rejected under 35 U.S.C. § 103a as being unpatentable over Hu in view of U.S. Patent No. 6,321,703 to Diehl *et al.* Applicants respectfully traverse the rejection and submit that the combination of cited prior art fails to show or suggest each and every element of claims 5-9.

Claims 5-9 depend upon claim 1 and are therefore patentable over Hu for at least the reasons already described above, and Diehl fails to cure the deficiencies of Hu. For instance, Hu describes a lost motion machine and not an electro-hydraulic system as defined by the claimed invention. Diehl describes an electro-hydraulic

system that includes fail safe mechanisms. That is, the system of Diehl is designed so that when there is a loss of power, the engine valves will fail to the shut position. Diehl does not teach or suggest anything about preventing engine valve-piston collision during regular operating conditions. Further, Diehl does not show a check valve between chamber 11 and reservoir 29 as asserted in the Office Action. Thus, Applicants submit that the combination of Diehl with Hu fails to disclose or suggest each and every element of claims 5-9 of the present invention. Accordingly, Applicants request that the rejection be withdrawn and claims 5-9 be allowed.

Claims 12-13 were rejected under 35 U.S.C. § 103a as being unpatentable over Hu in view of Hackett, and further in view of Diehl. Applicants' representative notes that this rejection appears to be directed towards claims 11-12 and not 12-13, and therefore, is being treated as such. Applicants traverse the rejection and submit that claims 12-13 recite subject matter not described or suggested by the combination of cited prior art.

As described above, Hu and Hackett, when combined, do not disclose or suggest each and every element of claim 10, upon which claims 12-13 depend. As described above with reference to claims 5-9, Diehl does not make up for the deficiencies of Hu, and similarly, fails to cure the deficiencies of Hackett. Thus, Applicants submit that the combination of cited prior art fails to show or suggest each and every element of claims 12-13. Accordingly, Applicants request that the rejection be withdrawn and claims 12-13 be allowed.

In view of the foregoing, Applicants request withdrawal of the rejection of claims 1-15 and request allowance of the present application.

If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the Applicants' undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this application.

In the event that this paper is not timely filled, the Applicants respectfully petition for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to Counsel's Deposit Account No. 02-2135.

Respectfully submitted,

By



Brian A. Tollefson
Attorney for Applicants
Registration No. 46,338
ROTHWELL, FIGG, ERNST & MANBECK, p.c.
Suite 800, 1425 K Street, N.W.
Washington, D.C. 20005
Telephone: (202)783-6040
Facsimile: (202) 783-6031